Hugh Wells W6WTU
1411 18th St.
Manhattan Beach CA 90266-4025

Inside Digital TV/VCR Tuners

Part 4: Testing and binary data format.

The first three parts of this series on digital TV/VCR tuners discussed the two types of tuners, along with control and the test system that I used during my study of the digital tuner. Specific subjects covered were the synthesizer used to control the local oscillator (VCO) within the tuner, a data transmitter used for sending control data to the tuner, and a data receiver used for observing the data that has been sent to the tuner. In this part of the series we will discuss "how to test" the digital tuner and will describe the methods for setting up the binary data format used for controlling a digital tuner.

The testing of a digital tuner is reasonably simple once a method has been developed for clocking serial data into the tuner. With a data transmitter, microcontroller, or computer operating as a controller, it's necessary only to enter band select information and frequency, and select data in a binary format for the tuner to operate. Upon receiving data in the correct format, the tuner functions in a manner like that of the more familiar analog varactor TV/VCR tuner. Binary formatted data is used to control the tuner's frequency synthesizer. **Fig. 1** shows the data sequence format from MSD on the left to LSD on the right.

The frequency synthesizer within the digital tuner has a main divider chain that sets up the frequency ratio between the tuner's local oscillator (VCO) frequency and the reference frequency applied to the reference port of the phase detector. When the divide ratio number is known, it is then converted from a decimal number to a binary number. In a binary format, the ratio number is clocked serially into the tuner's register.

For the TV/VCR digital tuners that I have encountered, the main divide ratio is determined by dividing the VCO frequency by 62.5 kHz. Some digital tuner synthesizers have optional step frequencies other than 62.5 kHz, but when used, the local oscillator (VCO) frequency band is altered to some degree. Gaining control of the optional step feature usually requires setting up the control data format to clock 34 bits of data instead of the normal 18/19 bits.

As an example of the process involved in finding the data format, choose a VCO frequency of 101 MHz, as is the case when the tuner is set for TV channel 2. Dividing 101 MHz by 62.5 kHz yields a divide ratio of 1616. Converting 1616 into a binary number provides the data format that can be clocked into the tuner's synthesizer. The binary conversion may be done using a great many different techniques, but the easiest is shown in **Fig. 2**. Although the use of a calculator will speed the conversion process, it isn't required when the indicated steps are followed. To help keep track of the final number and to verify the accuracy of the conversion, it is recommended that a worksheet as shown in **Fig. 2(b)** be used as a guide.

Method for calculation

Starting with the known information such as the desired oscillator frequency and the synthesizer step frequency, determine the decimal divide ratio that is needed to generate the desired oscillator frequency.

When the divider ratio is known, subtract the largest binary number from it. In the example, the divide ratio is 1616 and the largest binary number that can be subtracted from it is 1024. Subtracting 1024 from 1616 leaves a remainder of 592. A binary "1" is assigned to the location in the

MSD																	LSD
4	3	2	1	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Band Selectors				Frequency Select Data in Binary Format														

Fig. 1. Data format required for controlling a digital TV/VCR tuner.

Known	Desired oscillator (VCO) frequency = 101 MHz
	Synthesizer step frequency = 62.5 kHz
Find	Synthesizer divide ratio
	Binary number to be clocked into the tuner's register

Steps	N = divider ratio = OSC freq/step freq = 101 MHz/0.0625 = 1616						
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
	1616 – 1024 = 592	592 – 512 = 80	80 < 256	80 < 128	80 – 64 = 16	16 < 32	16 – 16 = 0
Assign	1	1	0	0	1	0	1

(a)

Osc. Freq.	N	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
101 MHz	1616	0	0	0	0	1	1	0	0	1	0	1	0	0	0	0
448 MHz	7168	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0

(b)

Fig. 2. Shows the required input information and the steps involved in converting a decimal number to a binary number. (a) Shows the steps used to find and convert from a decimal number to a binary number. (b) Shows how the binary number is charted in the desired format for clocking data into the digital tuner's register.

chart under the number 1024. A binary "1" is assigned each time a number can be subtracted from the remainder. A binary "0" is assigned in the location when a subtraction cannot be performed. In the case of the remainder "80" being smaller than "256," there is no subtraction so a binary "0" is assigned under the 256. Also in the example, 16 is the last number where a subtraction takes place which allows the assignment of "0" to all of the other binary locations.

So that the process of converting from a decimal number to a binary number is clear, a second example is provided in the chart for a VCO frequency of 448 MHz. In this case, a synthesizer divide ratio of 7168 will be required. As the subtraction process occurs, a binary "1" is placed in the columns headed up by 4096, 2048, and 1024. All remaining columns contain a binary "0".

In part five of this series I'll provide a BASIC program that will calculate the binary number for any tuner "receiver" frequency, along with the local oscillator frequency that is selected.

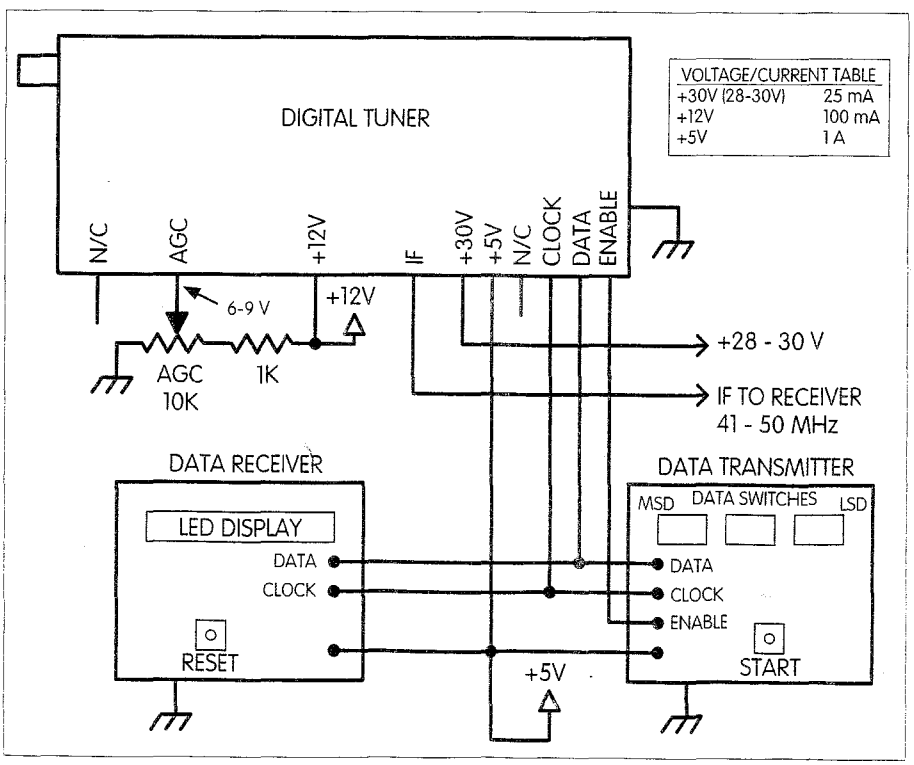


Fig. 3. Test setup and power for testing and/or using a 3-wire digital tuner.

Test setup

Fig. 3 shows the connections to the digital tuner, data transmitter, data receiver, and all of the power supply voltages. A voltage table is provided that may be used as a guide as to the typical current that the user should supply for operating all of the pieces contained in the test system.

Even though the figure is pretty clear as to how things are connected, a few words may help clear up any questions that might remain. All like terminal functions are tied together on all items. As an example, the data terminals on the tuner, data transmitter, and data receiver are connected together. The wires should be of short length and insulated, but shielding is not required. In other words, excess wire length should be avoided, but the units do not have to be crowded.

To gain a perspective on the physical layout of a digital tuner, refer to **Fig 4**. The two main areas of interest are the mixer/oscillator section, and the synthesizer section. The synthesizer section is readily identified because there will be a crystal mounted close by the synthesizer IC. In most tuners, the mixer/oscillator IC will be a surface mounted device soldered onto the circuit side of the circuit board (bottom side). Knowing the physical layout of the tuner becomes important during the test and checkout of the tuner.

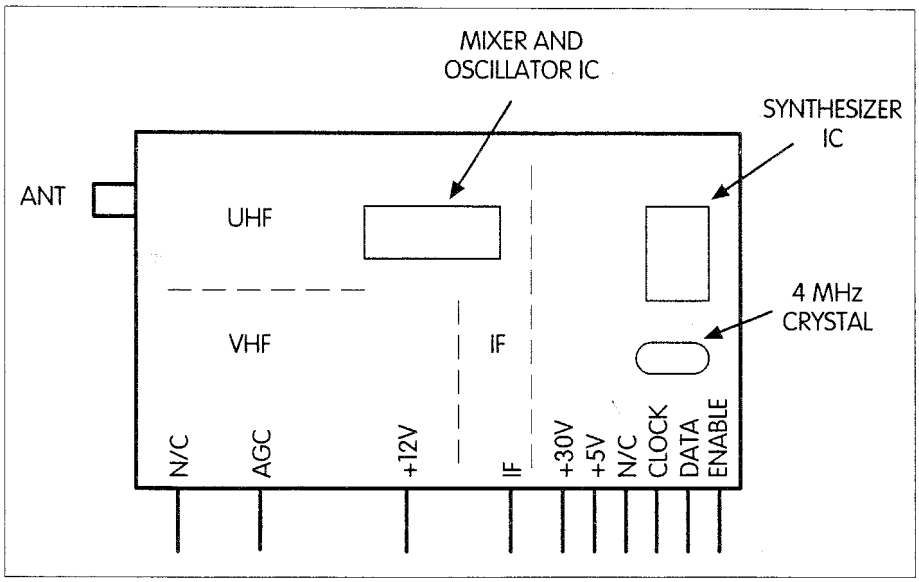


Fig. 4. Typical component placement and RF sections within a digital tuner.

Testing the tuner

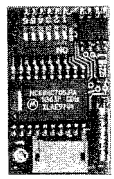
All of the required voltages must be applied to the tuner so that it will be active and ready to operate. The input data is entered into the tuner by setting the switches on the transmitter and pressing the "start" switch. The tuner resets for the next data entry whenever the ENABLE line goes HIGH. Data entered previously into the tuner is retained by the tuner as long as power is applied and the ENABLE line remains LOW.

Band and frequency select data can be sent to the tuner at any time after power is applied. But during the initial stages of testing, the data set position relative to how the synthesizer data register "sees" the data can be an unknown and requires some initial experimentation. Shifting the data bank back and forth a bit or two will usually suffice, but finding the MSD and or LSD bit location within the tuner's register may be a little elusive.

One technique that I've used that appears to work with most tuners, particularly those having a synthesizer chip with known band control pinouts

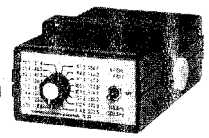
• DIP switch programmable
• Miniature in size
• 37 EIA tones, 27 non-standard tones from 33.0 to 254.1 Hz included
• Reverse Burst built-in
• Easy 3 wire hookup

SS-64 CTCSS Encoder
.66" x 1.08" x .21"



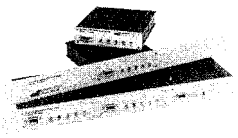
SS-64 DIP Switch Programmable CTCSS Encoder $28.95

• Fully enclosed CTCSS encoder
• All 32 EIA tones from 67.0 to 203.5 Hz included
• Perfect for mobile / base applications



TE-32
5.25" x 3.3" x 1.7"

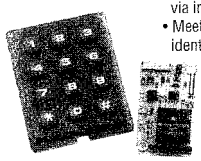
TE-32 Multi-Tone CTCSS Encoder $49.95



TP-3200 Shared Repeater Tone Panel

• 51 CTCSS Tones
• 106 DCS Codes
• Supports 157 Repeater Subscribers
• On-Line Computer Help
• Repeater CW ID
• Air Time Loading & Analysis Graphs
• Signalling Formats: CTCSS DCS & DTMF

• Eight programmable, selectable messages
• Fully field programmable via included keypad
• Meets all FCC identification requirements



TP-3200D Table Top Version $269.95 each
TP-3200RM-A Single Rack Mount version $279.95 each
*TP-3200RM-B Triple Rack Mount version $279.95 each
*Holds up to three TP-3200s

MasterCard VISA

ID-8 Automatic Morse Code Identifier
1.85" x 1.12" x .35"

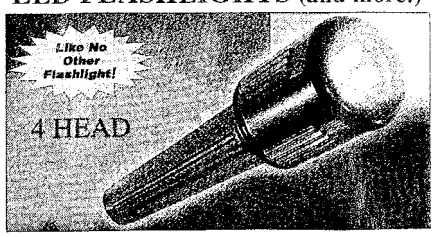
ID-8 Automatic Morse Station Identifier $69.95

Call or write to receive our full Product Catalog or visit our Web site for complete information at:
http://www.com-spec.com

COMMUNICATIONS SPECIALISTS, INC.
426 WEST TAFT AVENUE • ORANGE, CA 92865-4296
(714) 998-3021 • FAX (714) 974-3420
Entire U.S.A. (800) 854-0547 • FAX (800) 850-0547
http://www.com-spec.com

Be sure to let our advertisers know that you saw it in *73* Magazine!

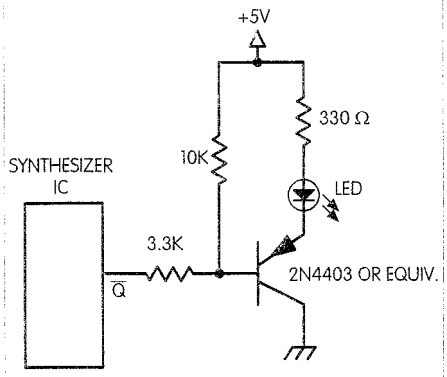
LED FLASHLIGHTS (and more!)



Colors: white, blue, red, and green
D & L Antenna Supply Co.
Secure Ordering On Line at
www.wavehunter.com
1-800-965-8880
Great Christmas Gift! ($4.95 and Up)

• Lasts 4 times longer than regular flashlights
• Lifetime warranty including LED lights
• Shockproof
• Features 4 high intensity LED lights
• Powered by 3 AA alkaline batteries

After continuously being turned on for 14 days (336 hours), it was possible to read a newspaper using only the output from this amazing system. This item sold out at Dayton!



Synthesizer IC Types & Pins

Motorola	MC44817D	Pin 15
Toshiba	TD6359 P/N	Pin 20
	TD 6380 P/N	Pin 20
	TD 6380 Z	Pin 16
	TD 6381 P/N	Pin 20
	TD 6381 Z	Pin 16
	TD 6382 P/N	Pin 20
	TD 6382 Z	Pin 16

Fig. 5. Synthesizer phase lock indicator. LED transistor driver is connected to the lock detector's output pin.

(one of four), is to measure the voltage on the selected pin. In the absence of known pinouts, tracing the tuner's band control transistor base circuits back to the synthesizer IC provides a level of confidence. A strong magnifying glass and an ohmmeter are usually required during the tracing process.

Once the band control pins have been identified, and with the data transmitter connected, enter only the "band" bits one at a time and attempt to determine with a voltmeter the band control terminal voltage that responds to a particular band bit sent by the data transmitter. The voltage on the band control pin will shift from an unselected voltage level of 12 V downward to a value below 7 V upon selection.

When the four band bits (of which only two or three are used) have been "mapped" on the data transmitter's switches, the first band bit (whether a "0" or a "1") to be clocked into the tuner is the MSD band bit, with the remaining three bits to follow. Because the band select bits are "pass-through," only one of four bits is selected for each of the tuner's bands.

The first frequency data bit (MSD) will be the first data bit that follows the fourth band bit. The LSD data bit will be the last bit to be clocked into the synthesizer. An illustration of the band and data bit format that is expected by the digital tuner was shown in **Fig. 1**.

A more random method for determining the data set position for the data transmitter's switches is to find the lowest LSD switch setting that affects the synthesizer's divide ratio. Counting the switches upward to 19 will identify the MSD position. With a step frequency of 62.5 kHz, the lowest LSD switch will shift the oscillator frequency by 62.5 kHz. The next lower switch will have no affect on the divide ratio.

One of the most helpful hints that I can provide is to suggest monitoring the synthesizer's "lock" feature. Entering data into the synthesizer and not knowing whether or not it's responding is quite unnerving at times. Most digital tuner synthesizer IC's have a dedicated pin that goes to a logic LOW when the system locks. Building up an LED driver circuit as shown in **Fig. 5** will provide visualization of what the synthesizer is doing. Connecting the LED driver, as shown, requires that a wire be soldered to the appropriate IC pin (IC pins are indicated for specific chips). This step should be avoided if you lack skill in soldering in cramped spaces. Excessive heat must be avoided to prevent damage to the synthesizer IC.

Of course, monitoring the local oscillator frequency with a frequency counter, when one is available, will provide direct feedback as to what the synthesizer is doing as well as indicate

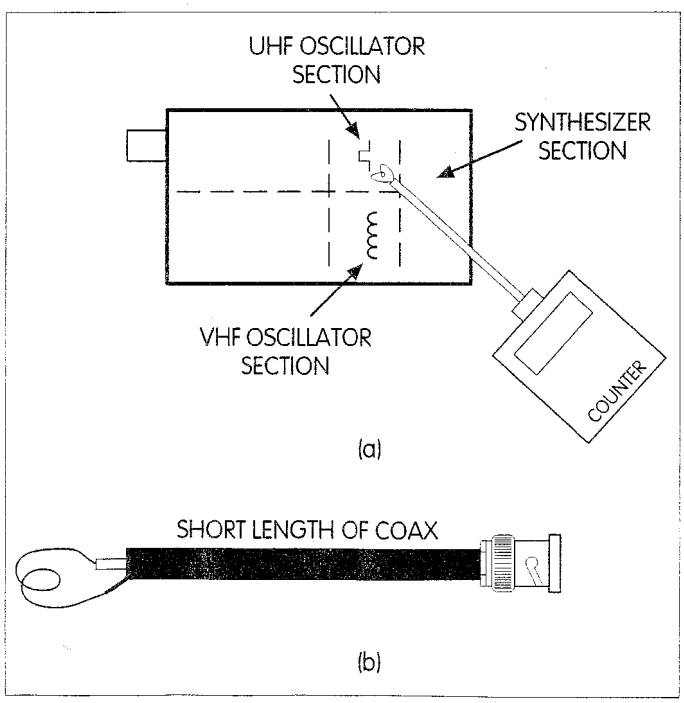
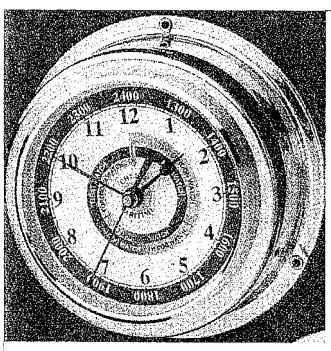


Fig. 6. Coupling signal energy from the tuner's VCO into a frequency counter. (a) Shows the approximate placement of the pickup coil. (b) Shows details of a suitable counter sampling probe. 2T insulated wire; coil diam. about 1/4"; coax type optional, RG-174, RG-58 work well.



Beautifully hand-polished.

Stamped brass case and bezel.

Curved glass crystal.

Wall or bulkhead mounting.

Made so well they last from generation to generation!

Order this month and save $20!

Chelsea Clock

Clockmakers since 1897

The choice of The Coast Guard Foundation.

Quartz Clock

4" Dial

Your price $75

Omega Sales

P.O. Box 376

Jaffrey NH 03452

1-800-467-7237

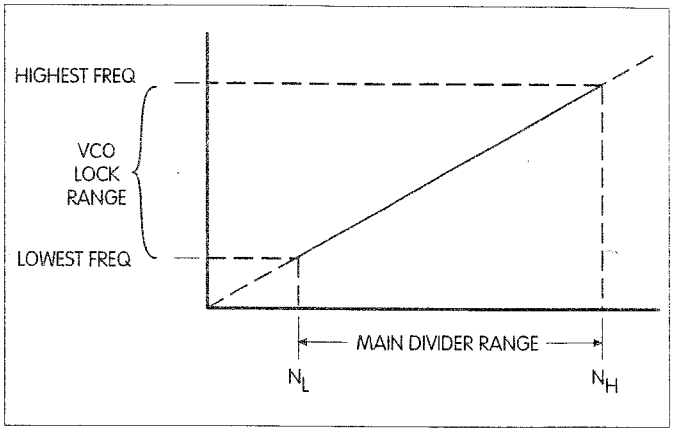


Fig. 7. VCO lock range as a function of the divide ratio of the main synthesizer divider. Dotted ends indicate ambiguity of the lock range per individual tuner.

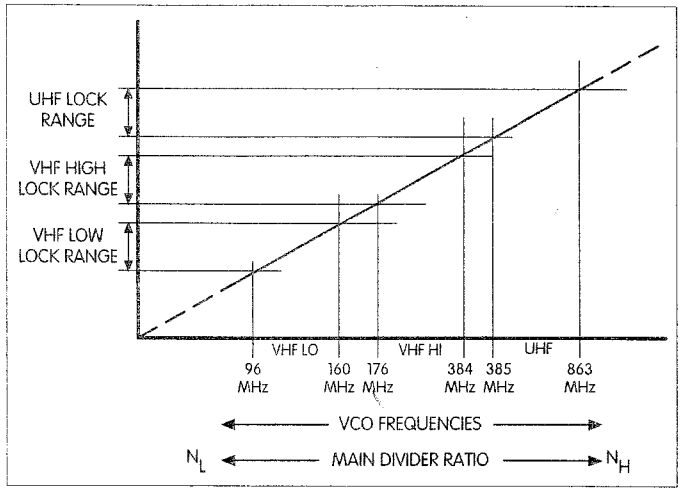


Fig. 8. Typical VCO tuning curve showing frequency vs. lock range.

the frequency of VCO operation. Coupling is provided to the counter through a small pickup loop that is placed adjacent to the oscillator coils within the tuner. **Fig. 6** shows the details of the pickup loop and typical placement within the tuner. A tight coupling between the coupling loop and the oscillator coil is usually needed to achieve a "good" count.

Tuner response

One of the problems that I encountered during the initial test period was determining if and how the tuner might be responding. The use of the counter and "lock" indicator were of great assistance to me. Perhaps not knowing the band edges was the biggest deterrent.

To share my findings regarding the band limits and VCO lock capability, I've developed two charts shown in **Figs. 7** and **8**. The first chart is an expanded section showing the VCO tuning ramp from the lowest to the highest divide ratio for a given band. The VCO in various tuners has been set up to "lock" within the frequency requirements of the TV channels. But in some cases, the VCO will lock at a band of frequencies wider than the TV requirements, as indicated by the dotted lines representing the lock ambiguity. During initial testing, finding the near center frequency in each band provides the best opportunity of getting a "lock." Locating the lowest and highest frequency for each band is done by changing the divide ratio incrementally until the synthesizer drops out of lock.

Fig. 8 shows the typical VCO tuning curve and band by frequency. Some tuners exhibit a band gap between segments and others do not, which is a function of the lock ambiguity. The frequencies shown in the chart are the typical band limits that may be used for finding the near band center "lock" frequency during initial testing.

What's next

Parts five, six, and seven of this series on TV/VCR digital tuners will follow. Part five will provide a BASIC program that will allow the conversion of decimal frequency numbers to binary control numbers as required for tuner synthesizer control. Parts six and seven will wrap up the digital tuner discussion with a procedure for making printed circuit boards. 73

ELECTRONIC MILITARY SURPLUS
FAIR RADIO SALES
Capacitors - Motors - Relays - Power Supplies - Test Equipment
Radios - Antennas - Roller Inductors - Transformers - Wire - Tubes
30 FT MAST KIT
AB-1244/GRC MAST KIT, twelve aluminum alloy on steel sections form sturdy, yet lightweight 30 foot 1.7" dia mast. Kit in-cludes five each lower and upper sections, one ea lower and upper adapter sections, gin pole swivel base, four ea 36 and 42 ft guy ropes, four guy stakes, two guy rings plus 2.5 pound sledge hammer. Part of OE-254/ GRC antenna set; 30 lb sh. NEW, $139.50
NYLON BAG for above. New, $39.50; See Web.
Electron Tubes, JAN-BOXED unused:
4CX300A Eimac, $45.00
4CX5000J imac, $650
4D32 Raytheon, $28.00
6AJ5 Tung-sol, $3.50
811A Cetron, $25.00
955 Hytron, $3.50
1625 Nat. Union, $4.50
5998A Sylvania, $9.95
6336B Cetron, $30
6922 ECG, $3.50
7308 Amperex, $3.50
7360 ECG, $15.00
Allow money for shipping on merchandise.
WEBSITE: fairradio.com
E-MAIL: fairadio@wcoil.com
PHONE: 419-227-6573 - FAX: 419-227-1313
1016 E. Eureka - Box 1105 Lima, OH 45802
VISA, MASTERCARD, DISCOVER accepted
Write for latest Catalog - Address Dept. 73

Amplifiers, ATV Down Converters & Hard to Find Parts
LINEAR AMPLIFIERS
HF Amplifiers
PC board and complete parts list for HF amplifiers described in the Motorola Application Notes and Engineering Bulletins:
AN779[1] (20W) AN758 (300W)
AN779[] (20W) AR313 (300W)
AN762 (140W) BD27A (300W)
BB63 (140W) BB104 (600W)
AR305 (300W) AR347 (1000W)
2 Meter Amplifiers (144-148 MHz)
(Kit or Wired and Tested)
35W - Model 335A.. $79.95/$109.95
75W - Model 875A.. $119.95/$159.95
HARD TO FIND PARTS
• RF Power Transistors
• Broadband HF Transformers
• Chip Caps - Kemet/ATC
• Metalclad Mica Caps - Unelco-Semco
• ARCO/SPRAGUE Trimmer Capacitors
We can get you virtually any RF transistor! Call us for "strange" hard to find parts!
DIGITAL FREQUENCY READOUT
For older analog transceivers
TK-1 (Wired and Tested) $149.95
ATV Down Converters
(Kit or Wired and Tested)
Model ATV-3 (420-450) (GaAS - FET) $49.95/$69.95
Model ATV-4 (902-926) (GaAS - FET) $59.95/$79.95
For detailed information and prices, call or write for our free catalog
ADDITIONAL ITEMS
Heat Sink Material
Model 99 Heat Sink (6.5" x 12" x 1.6"). $24
CHS-8 Copper Spreader (8"x 6" x 3/8"). $24
Low Pass Filters (up to 300W) for harmonics $12.95
Specify 10M, 15M, 20M, 40M, 80M or 160M
HF Splitters and Combiners up to 2KW
Phone (937) 426-8600
FAX (937) 429-3811
cci Communication Concepts Inc.
508 Millstone Drive • Beavercreek, Ohio 45434-5840
e-mail: cci.dayton@pobox.com
www.communication-concepts.com